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Evaluation of Right Ventricular Function in Chronic Renal Failure Patients on Regular Hemodialysis Therapy (Tissue Doppler Imaging Study)

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ABSTRACT

Background: Major contributors to mortality and disability among patients diagnosed with end-stage renal disease are cardiovascular disorders. Initial manifestations of cardiovascular function may even be managed while dependent on dialysis. Those patients are prone to developing severe progressive cardiovascular events and pulmonary artery hypertension, which occur frequently during prolonged hemodialysis. The overall prevalence of these complications ranges from 19 to 70%. **Objective:** To assess right ventricle (RV) functions in chronic renal failure patients on dialysis by myocardial performance index RV inferred from tissue Doppler imaging (TDI) (MPI-RV).

Patients and methods: The study involved 100 chronic renal failure patients on dialysis, proved by tissue Doppler echocardiography, in the cardiovascular Department of the Faculty of Medicine, Al-Azhar University Hospital (Assiut), and the Cardiac Department of Al Helal Hospital (Sohage), during the period from November 2017 to May 2019.

Results: A noteworthy positive correlation was observed between duration of dialysis and RV diastolic values; however, no significant negative correlation was found between duration of dialysis and deceleration time (m/s); TV E/E' was not significantly correlated with duration of dialysis; the correlation between TV E/A and dialysis duration was significant.; frequency of dialysis was not significantly correlated with IVRT (m/s); and the frequency of dialysis did not exhibit a statistically significant positive correlation with TV E/A. **Conclusions**: TDI can detect RV function changes in hemodialysis patients at an early stage. Early diagnosis facilitates timely interventions, which are presently restricted to referrals for kidney transplantation or modifications in dialysis modality.

Keywords: Renal hemodialysis, Tissue Doppler echocardiography, RV function.

INTRODUCTION

Cardiovascular disorders contribute greatly to mortality and disability among end-stage renal disease (ESRD) patients. Globally, cardiovascular disease has been identified as the cause of approximately 40 % of all documented cases of death in this patient subgroup [1]. Therefore, it appears that the initial manifestations of cardiovascular function may be managed even in the presence of dialysis. Patients undergoing prolonged hemodialysis are frequently afflicted with pulmonary artery hypertension, a severe progressive cardiovascular event, in addition to myocardial dysfunction, which affects ESRD patients at a prevalence rate ranging from 19 to 70% [2]. Echocardiography is a stabilised method utilised to evaluate the function of the ventricles of the heart [3]. It is recommended that ESRD patients who are candidates for dialysis undergo screening with Doppler echocardiography as the gold standard for assessing PAH [4]. Additionally, tissue Doppler imaging (TDI) can detect right ventricle (RV) function changes in hemodialysis patients at an early stage. Early diagnosis allows for timely interventions, which are presently restricted to modifications in dialysis modality or patient referrals for kidney transplantation [5]. The identification of patients who are at an increased risk of developing heart failure could potentially be facilitated through the detection of subclinical RV dysfunction in ESRD patients prior to dialysis. TDI has been regarded as a dependable prognostic indicator and an precise and reproducible method for detecting preclinical ventricular abnormalities through the evaluation of RV function [6].

RV dysfunction in patients with ESRD has received considerably less attention than LV (left ventricle) dysfunction in the majority of available studies. This is crucial, as increased morbidity and mortality have been linked to RV dysfunction in numerous cardiovascular diseases [7]. As a validated indicator of LV diastolic or systolic dysfunctions, RV and atrial functions, TDI measurements are documented in a variety of cardiac conditions [8].

We aimed to evaluate the functionality of the RV in patients undergoing dialysis for chronic renal failure using a myocardial performance index of RV (MPI-RV) derived from TDI.

PATIENTS AND METHODS

The study included 100 patients with chronic renal failure on dialysis, proved by tissue Doppler echocardiography, in the Cardiovascular Department of the Faculty of Medicine, Al-Azhar University Hospital (Assiut), and the Cardiovascular Department of Al Helal Hospital (Sohage) (Approval code: Rc 25-5-2017), during the period from November 2017 to May 2019.

Inclusion criteria: Chronic renal patients on dialysis.

Exclusion Criteria: Hypertensive patients mainly the chronic ones, age younger than 15 years or older than 70 years, diabetic patients, chronic artery disease, pericardial effusion accompanied by echocardiographically detectable cardiac compression, significant valvular

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lesions, constrictive pericarditis, hemoglobin level < 6 gm/dl, congenital defects and pulmonary HTN secondary to Lt sided or chronic parenchymal lung diseases patients.
The following was done for all patients: Informed consent, detailed clinical history taking (history of smoking, previous occupational exposure, chronic lung disease, cardiac condition or similar cases in family), clinical evaluation (complete general, cardiac and chest examination), ECG evaluation (resting 12 lead electrocardiograms in supine position by Cardiomax Fukuda Denshi model FX7102) ***(Japan),*** laboratory assessment (all routine lab tests),

Echocardiography evaluation [9]: Utilization of a vivid seven-phased array system, complete transthoracic echocardiographic examination was done, including tissue Doppler echocardiography, and conventional echocardiography. All echocardiographic examinations were conducted after a patient achieving quiet respiration for 20-30 minutes in the partial left lateral decubitus position. Utilizing of a 2-4 MHz transducer was to obtain the following views and modalities: Color Doppler echo, M mode echo, PW and CW Doppler, 2D echo, and pulsed TDI. The parameters utilized were MPI-TDI, TAPSE, FAC, S wave, and RV diastolic function. Chest X-rays and pulmonary function tests were also performed.
The values for each echocardiographic parameter were calculated using the American Society of Echocardiography's method of be an average of measurements from three consecutive cardiac cycles. All measurements were acquired online.

Fractional Area Change (FAC): is determined by tracing the RV endocardium during systole and diastole along the interventricular septum from and back to the annulus, along the free wall to the apex. The free wall beneath the trabeculations must be carefully traced. FAC represents the percentage difference between the diastolic and systolic values (Typically: 35–60%) [10].

Tricuspid Annular Peak Systolic Excursion (TAPSE) and lateral): is determined by passing an M-mode cursor through the tricuspid annulus while measuring the amount of longitudinal motion at peak systole (16 cm; normal value) [11].

Positive peak systolic velocity (S wave): The velocities of the tricuspid annular canal were determined by activating the DTI function of the echocardiography machine and employing pulsed-wave DTI. A phased array transducer with variable frequency (2.0-4.0 MHz) was utilized. After maintaining the filter settings at a low frequency of 50 Hz, the gains were optimized to ensure velocity of high quality. Regarding the apical four chambers. When longitudinal contraction of the RV caused the tricuspid annulus to approach the cardiac apex (S wave normally or equal to 10 cm), the positive peak systolic velocity was computed [11].

Myocardial performance index by TDI (MPI-TDI) [12]**:** This was accomplished through the measurement of TDI velocity time intervals from the mitral annulus sites on the septal and lateral segments. The TDI isovolumetric contraction time was determined by timing the transition from the termination of the A wave to the initiation of the S wave. The TDI ejection time (ET) was calculated from the beginning of S' wave until it ended. The TDI isovolumetric relaxation time (IRT) was calculated from the moment the S wave ceased to the moment the E' wave began. The formula for MPI-TDI was (ICT-IRT)/(ET).

Measurement of RV Diastolic Function: When viewed from the apical four chambers, the Doppler beam had to be parallel to the RV inflow. Placing the sample volume at the tips of the tricuspid leaflets can aid in achieving proper alignment by relocating the transducer medially toward the lower parasternal region. Conducting transtricuspid flow velocity measurements can be done in the majority of patients using this method, which features minimal interobserver and intraobserver variability and is effective for identifying [13]. Deceleration time (DT) is quantified along the tricuspid flow's descending slope of A wave [14], isovolumic relaxation time: quantified using TDI-PWD at the basal lateral wall of the right ventricle, spanning from the end point of the systolic velocity wave (S wave) to the initiation of the early diastolic wave (E wave) (usually below 75 ms), E/A ratio: (normally >0.8), and TV E/E ratio: Determined by TDI-PWD from the tricuspid annulus's movement toward the base away from the apex in order to obtain the tricuspid inflow early diastolic velocity wave E (normally < 8) [13].

Ethical approval:

The study was approved by the Ethics Board of Al-Azhar University, Rc 25-5-2017 and an informed written consent was taken from each participant or their parents in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical methods

An SPSS v26 statistical analysis was performed (IBM Inc., Armonk, NY, USA). For quantitative variables, the mean and standard deviation (SD) were provided. Q qualitative variables consisted of frequencies and (percent). Pearson correlation was utilised to determine the extent of correlation between two quantitative variables. A two-tailed P value less than 0.05 was deemed to indicate statistical significance.

RESULTS

The results will be discussed according to different parameter as follows: -

1- Age: for more evaluation of age, we allocated the patients into different age groups. More patients were in the group from 60 to 70 years (Table 1).

Table (1): The distribution of patients in different age groups

Age groups	Count	Table N %
From 20 to 30	4	4%
From 31 to 39	5	5%
From 40 to 49	26	26%
From 50 to 59	27	27%
From 60 to 70	38	38%

2- Gender: The number of males was almost equal to that of females (Table 2).

Table (2): The distribution of patients in gender

Gender groups	Count	Table N %
Female	51	51%
Male	49	49%

3- Correlation between parameter of dialysis and RV systolic function using TDI was not significant (Table 3).

Table (3): Correlation between the duration and frequency of dialysis and the values of RV systolic functions

Dialysis / TDI	Duration of dialysis			Frequency of dialysis		
Value	**Mean ± SD**	**Correlation Coefficient**	**P Value**	**Mean ± SD**	**Correlation Coefficient**	**P Value**
Sys TABSE (mm)	21.41±4.133	-0.088	0.382		0.741	0.466
Sys FAC %	31.731±2.2406	0.089	0.381	31.731±2.2406	-0.147	0.145
Sys MPI_TDI	0.4376± 0.05352	0.178	0.076	0.4376± 0.05352	-0.145	0.149
Sys S wave (cm/s)	9.993±1.135	0.014	0.891	9.993±1.135	0.044	0.661

4- Correlations between Frequency of dialysis and RV diastolic functions (Tables 4 - 5)

Regarding the diastolic functions of TDI, a notable positive correlation was identified between dialysis duration and each of IVRT and dialysis duration and TV E/A (Table 4).

Table (4): Correlation between the duration of dialysis and deceleration time, IVRT, TV E/A and TV E/E´ in TDI

		DT in TDI (m/s)	IVRT (m/s)	TV E/E´	TV E/A
Duration of dialysis (years)	**Pearson correlation (R)**	-0.033	0.395	-0.065-	0.206
	P value	P > 0.05	P < 0.05	P > 0.05	P < 0.05
	Significance	Insignificant Negative correlation	Significant Positive correlation	Insignificant Negative correlation	Significant Positive correlation

Correlations between frequency of dialysis and RV diastolic functions was not significant (Table 5).

Table (5): Correlation between the frequency of dialysis and IVRT, DT, TV E/E´ and TV E/A in TDI

		IVRT	DT (m/s)	TV E/E´	TV E/A
Frequency of dialysis (weeks)	**Pearson correlation (R)**	-0.040	0.040	0.028	0.007
	P value	P > 0.05	P > 0.05	P > 0.05	P > 0.05
	Significance	Insignificant Negative correlation	Insignificant Positive correlation	Insignificant Positive correlation	Insignificant Positive correlation

DISCUSSION

The parameters of diastolic and systolic RV function as well as TD parameters differed significantly, according to a comparative analysis of echocardiographic Doppler parameters. [15]

In our study, lateral TDI Sa values, which reflect RV systolic parameters, did not differ significantly between the groups. We did not detect a significant reduction in RV functionality when we assessed it globally.

There were marked significant changes in PASP with duration of dialysis as in a long duration there was a significant increase at pulmonary pressure.

According to diastolic functions of TDI, there was significant positive correlation between the duration the duration of dialysis and IVRT, insignificant negative correlation between the duration of dialysis and DT, insignificant negative correlation between the duration of dialysis and TV E/E´, significant positive correlation between the duration the duration of dialysis and TV E/A. So, in chronic renal patients on hemodialysis with long periods, there was an affection in RV diastolic functions leads to RV diastolic dysfunction.

Our results came in agreement with: -

As stated by **Wells and Dransfield** [5], the parameters of RV systolic function, including RVs' velocity, are found to be preload independent in ESRD patients who undergo regular hemodialysis. In contrast, it is observed that the conventional parameters of the RV diastolic function are dependent on the preload in this particular population.

Tunariu *et al.* [16] demonstrated that acute variations in electrolytes, volume status, and autonomic regulation during hemodialysis sessions did not have an impact on LV diastolic and RV functions.

Pulmonary pressure values associated to RVD, HD treatment. They demonstrated that after hemodialysis, RV function indicators such as RV S' velocity did not differ significantly. The RVFAC, RV, MPI-RV, and TAPSE values, on the other hand, increased significantly, and they identified TAPSE as the sole parameter that exhibited a positive correlation with the quantity of fluid extracted.

Prior research has documented that individuals undergoing chronic dialysis exhibit a greater prevalence of pulmonary hypertension, with HD treatment accounting for 56% of the total. [17]

MPI is considered to be a highly accurate indicator of ventricular performance due to its incorporation of parameters that are associated with both cardiac contraction and relaxation. Furthermore, estimation of MPI via tissue Doppler analysis is comparatively unaffected by intravascular volume reduction subsequent to HD [18].

Our results came in disagreement with: -

A study was conducted by **Fukui *et al.*** [19] to examine the impact of reduced preload on the systolic function of the RV in patients with HD by utilizing echocardiographic parameters. RV Sa velocity was discovered to be preload independent, while MPI, RV FAC, and TAPSE values were found to be preload dependent. They reported that HD significantly increased the TAPSE value, whereas dialysis had no significant effect on the RV MPI and Sa values. While the TAPSE value was dependent on preload, neither the MPI nor S' values were.

Arteriovenous fistula and ESRD are associated with dysfunction of the right ventricle, according to **Abraham *et al***. [12]. Conventional Doppler echocardiography reveals a significantly lower RV ejection fraction, while septal and lateral TDIMPI are significantly higher at the tricuspid annulus. This association is independent of high systolic pulmonary artery pressure.

Regarding RV function in ESRD patients, knowledge has lagged significantly behind that of the LV. There are currently no available data pertaining to RV in patients with ESRD who are initiating dialysis therapy.

Significant proportions of ESRD patients undergoing hemodialysis also suffer from pulmonary hypertension, and the occurrence or exacerbation of RV dysfunction is associated with higher rates of morbidity and mortality in that group. [20, 21].

Limitations: The study included only 2 medical centre, small sample size to consolidate our findings and prognostic significance in the patients could also be investigated through follow-up. More information is required for extensive studies.

Recommendations: We recommend using TDI in all renal patients to evaluate the RV functions and also, ESRD patients on dialysis must be evaluated by conventional and tissue Doppler echocardiography.

CONCLUSION

TDI can detect RV function changes in hemodialysis patients at an early stage. Early diagnosis facilitates timely interventions, which are presently restricted to referrals for kidney transplantation or modifications in dialysis modality.

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